

## Homework 4 (due Feb 18)

1. A betatron accelerates electrons to a kinetic energy of 300 MeV. Its radius is 1 m. Calculate the magnetic field at the orbit and its flux through the orbit at 300 MeV.
2. The Fermilab Booster is a synchrotron used to accelerate protons from a kinetic energy of 400 MeV up to 8 GeV. Its circumference is 468 m. The accelerating radiofrequency (rf) cavities operate at the 84th harmonic of the revolution frequency. Calculate by how much the rf frequency must vary during acceleration.
3. In an asymmetric collider, a beam of particles of mass  $m_A$  and four-momentum  $(E_A, 0, 0, p_A)$  collides head-on with a beam of particles of mass  $m_B$  and four-momentum  $(E_B, 0, 0, -p_B)$ .

Find an expression for the center-of-mass (cm) energy  $W$  and apply your formula to calculate the cm energy of the KEKB collider in Japan, where 8 GeV electrons collide with 3.5 GeV positrons.